$Z \longrightarrow 4\ell$ production resonance cross section at ATLAS

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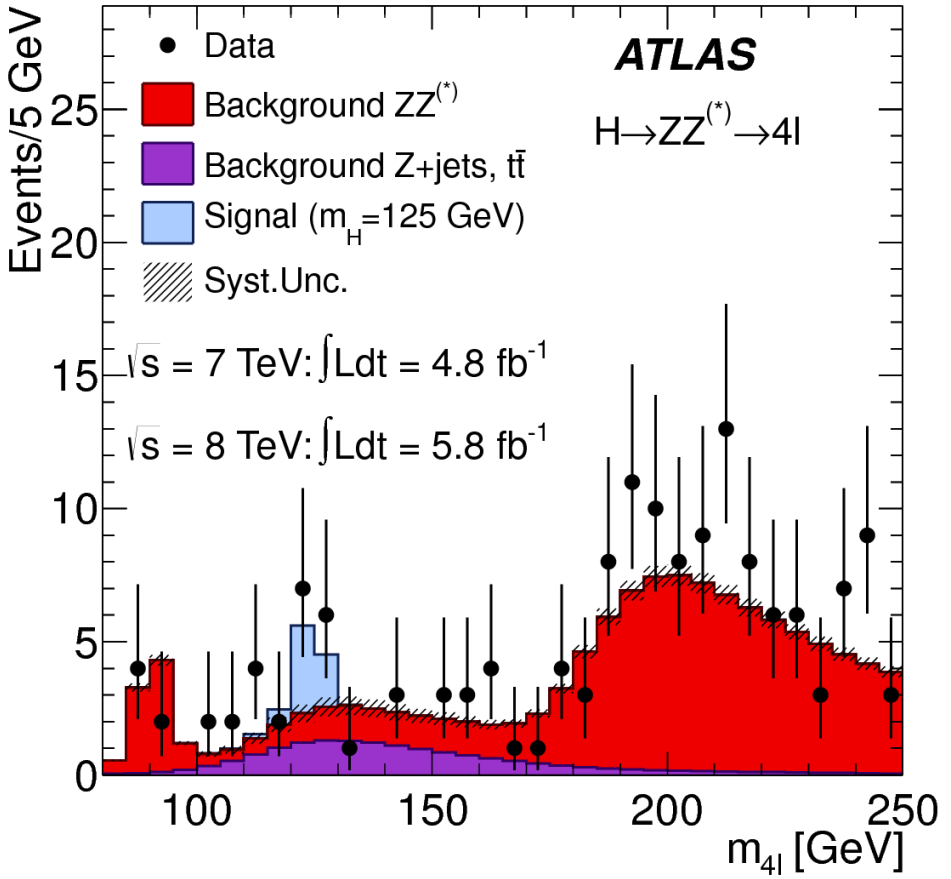
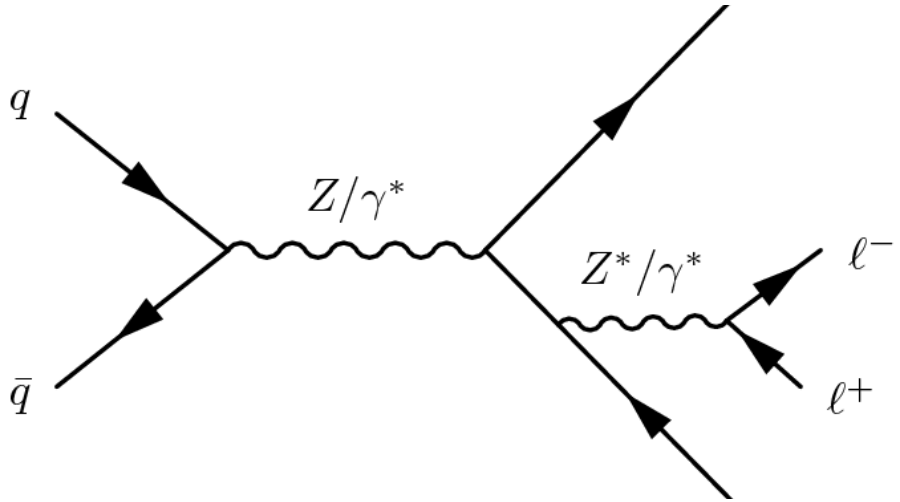
Motivation

- To check standard model predictions
- Checking the ATLAS detector response using a well understood process with the same final state as the Higgs Boson in a useful range for its study

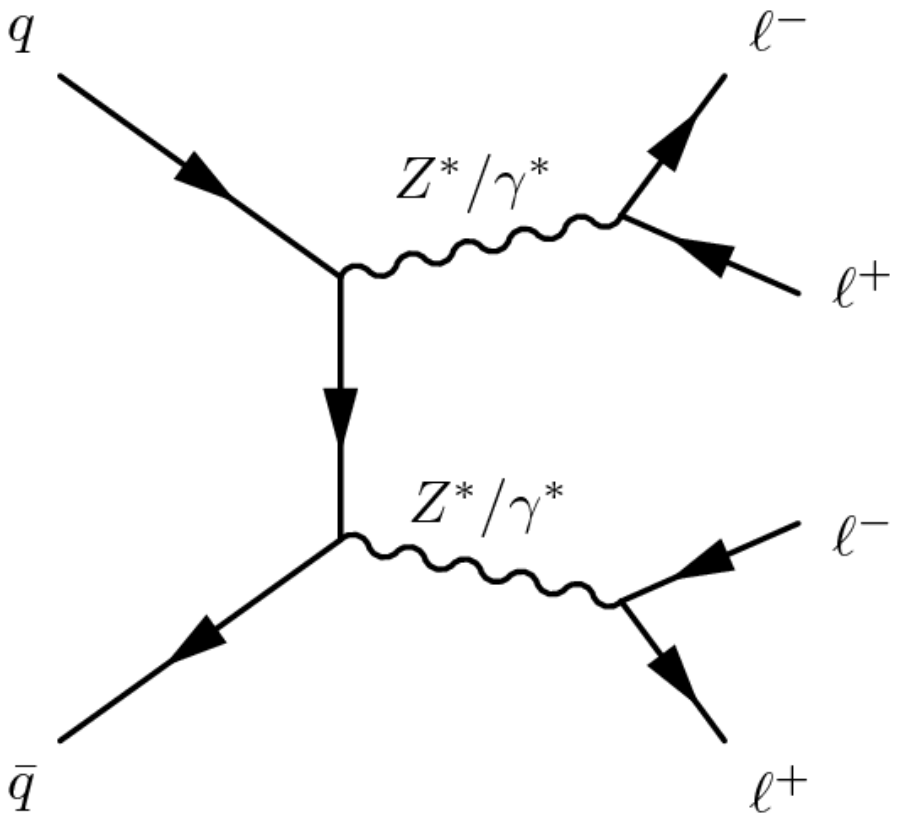


ATLAS Collaboration. Observation of a new particle in the search for the standard model Higgs Boson with the ATLAS detector at the LHC. Physics Letters B, 716(1):1 – 29, 2012.

Z $\longrightarrow$ 4ℓ processes



Resonant



Non Resonant

What are we looking for

- Look in the mass range $80 < m_{4\ell} < 100$ GeV
- E_T deposited in calorimeter in the cone $\Delta R = 0.2$ around the lepton is required to be less than 30-15% of lepton E_T, depending on the pp collision energy and the flavour of the lepton
- Only look for isolated leptons (the scalar sum of the p_T of the other tracks in the cone $\Delta R = 0.2$ is less than 15% of lepton p_T)
- Leptons must be separated by at least $\Delta R = 0.1$
- Impact parameter less than 3.5σ for muons and 6.0σ for electrons
- Fiducial region is $|\eta| < 2.5$ for electrons and < 2.7 for muons

Selections based on lepton p_T

- Highest energy leptons must have $p_T > 20$ and 15 GeV respectively
- Third lepton must have $p_T > 8$ GeV for a muon, or 10 GeV for an electron
- Fourth lepton must have $p_T > 4$ GeV for a muon, or 7 GeV for an electron
- After lepton pairs have been selected, they must satisfy $m_{12} > 20$ GeV and $m_{34} > 5$ GeV

Standard Model Prediction

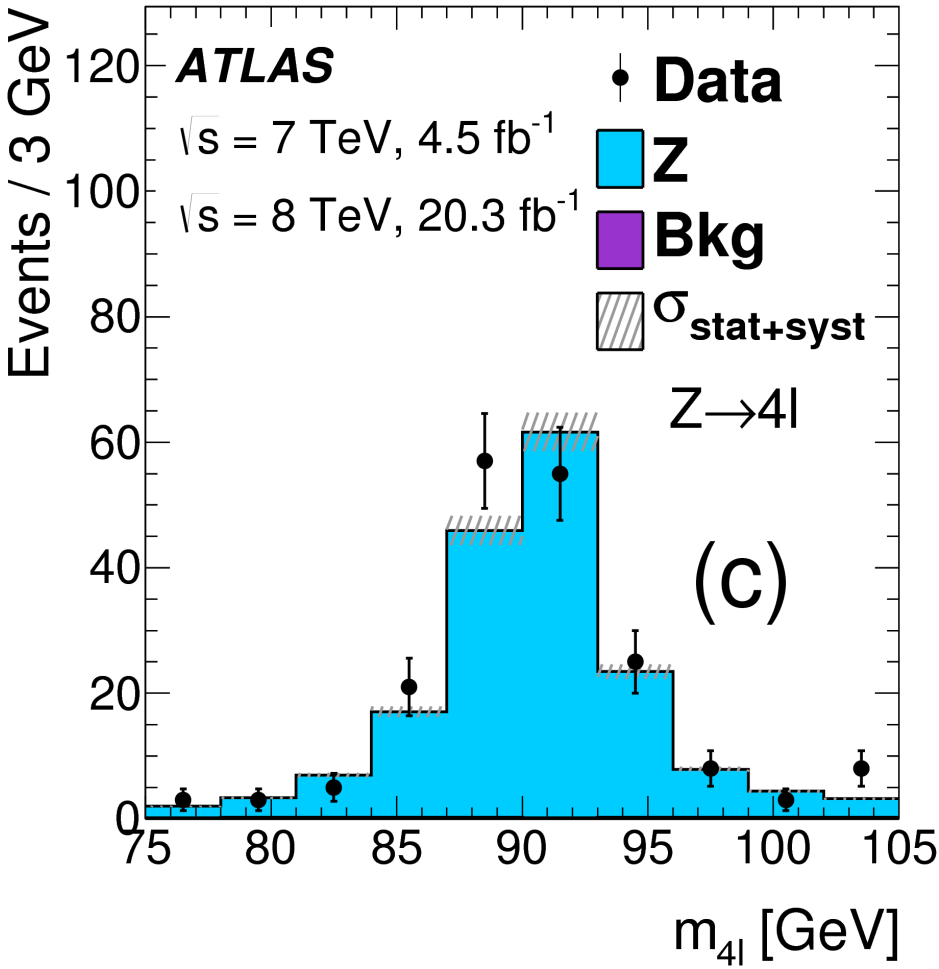
- Predictions were made by running Monte Carlo simulations including perturbative QCD correction to NLO, detector efficiency and phase space restrictions
- Predicted events 23.8 ± 1.2 in the 7 TeV data and 145 ± 7 in the 8 TeV data
- Expected Branching Fraction: $(3.33 \pm 0.01) \times 10^{-6}$
- Expected cross section: 90.0 ± 2.1 fb at 7 TeV and 104.8 ± 2.5 fb at 8 TeV

Uncertainties

- The low number of events means the uncertainties are dominated by statistics
- There are also significant systematic uncertainties, coming from lepton reconstruction and identification efficiencies and uncertainties on the luminosity

Results

- Detected 21 events in 7 TeV data and 151 in 8 TeV data
- Determine the branching fraction by normalizing the production rate to the $Z \longrightarrow \mu^+\mu^-$ rate in the same data set
- Hence compute cross section



Branching fraction

$$\frac{\Gamma_{Z\to 4\ell}}{\Gamma_Z} = \left(\frac{\Gamma_{Z\to\mu\mu}}{\Gamma_Z}\right)\frac{(N_{4\ell}^{obs} - N_{4\ell}^{bkg})(1 - f_{nr})C_{2\mu}A_{2\mu}}{(N_{2\mu}^{obs} - N_{2\mu}^{bgk})C_{4\ell}A_{4\ell}}$$

$Z\to\mu\mu$ branching fraction

Non-resonant fraction

Number of s-resonance events

Number of $Z\to\mu\mu$ events

Efficiency and acceptance factors

Results

- Measured branching fraction: $(3.20 \pm 0.25\ (\text{stat}) \pm 0.13\ (\text{syst})) \times 10^{-6}$
- Result in agreement with the Standard Model prediction: $(3.33 \pm 0.01) \times 10^{-6}$
- Phase space increased to match a previous measurement by CMS, and the calculated branching fraction agrees with the CMS result

Results

- Calculate cross sections to be 76 ± 18 (stat) ± 4 (syst) ± 1.4 (lumi) fb at 7 TeV and 107 ± 9 (stat) ± 4 (syst) ± 3.0 (lumi) fb at 8 TeV
- In agreement with the standard model prediction: 90.0 ± 2.1 fb at 7 TeV and 104.8 ± 2.5 fb at 8 TeV

Thank You!